DESIGN GUIDELINES FOR ELASTOMERIC BEARINGS

Elastomeric bearings shall consist of either plain elastomeric pads or steel-reinforced laminated pads.

The bearings may be designed by either Method A (Article 14.7.6) or Method B (Article 14.7.5) of the AASHTO LRFD Bridge Design Specifications.

Method A is the required design procedure for plain elastomeric pads and it is the preferred design procedure for steel-reinforced bearings. This design procedure is simpler and does not require the long term load test specified for bearings designed under Method B.

Design Method B and/or the use of Grade 4 elastomer requires that a long term load test be preformed on at least 10% of the completed bearings per ITD Standard Specifications, Subsection 711.02 (5e). Because these test are time consuming Method B should be used only when the magnitudes of the loads and/or rotations are such that Method A does not result in a practical bearing size or in those areas where Grade 4 elastomer is required (since Grade 4 elastomer requires the same testing as bearings designed by Method B, Method B should be utilized when Grade 4 is required). When Method B or Grade 4 elastomer is used it should be clearly noted in the plans and also mentioned in the Contractor's Notes of the Special Provisions to ensure that the correct testing is performed.

The elastomeric material shall be specified by its hardness and grade. Most bearing designs for both Method A and B should be based on 60 durometer elastomer, Grade 3. The shear modulus for 60 durometer elastomer shall be assumed to range from 130 psi to 200 psi, with the least favorable value being used for the particular design parameter being considered. Grade 4 elastomer should be specified when the bridge is located in low temperature Zone D, if Grade 3 is used in Zone D the other components of the bridge must be designed to resist 1.5 times the shear force determined by Article 14.6.3.1 when a low friction sliding surface is used or 4 times this shear force for a non-sliding surface (see Article 14.7.5.2). Zone D for Idaho shall be defined as any area above an elevation of 3800 feet or any location in Bonner or Boundary County.

Grade 4 elastomer should specify polyisoprene material (natural rubber) on the plans. Grade 3 elastomer should specify polychloroprene material (neoprene) on the plans.

Live load reactions when determining the maximum bearing reaction shall be based on the girder distribution factor for shear, Article 4.6.2.2.3. Live load rotations and associated reactions when checking rotations shall be based on the girder distribution for moment, Article 4.6.2.2.2.

All loads and rotations used in bearing design shall be determined using the Service I limit state including dynamic load allowance (IM).

Bearing Design Criteria for Prestressed/Precast Concrete Girders

For the purpose of simplification all girder reactions for prestressed girders may be based on simple span analysis, even if the girders are made continuous for composite loads. However, the live load rotations may still be determined assuming continuous action.

The instantaneous compressive deflection (LL and IM only) shall be less than 1/8". The long term compressive deflection due to dead load including creep shall be limited to 3/16" (the value of 3/16" for the allowable long term compressive deflection is considered acceptable for smoothness of ride without restricting the design of the bearings unnecessarily).

For expansion bearings without a sliding surface shear deformation shall be determined from the combined effects of thermal, creep and shrinkage movements of the structure. The thermal movement shall be based on the difference between the assumed temperature at placement (normally 60º F per ITD Bridge Design Manual Article 3.12.2.1) and a low temperature of 0° F per LRFD Article 3.12.3.1. A creep and shrinkage factor of 0.0002 may be used in lieu of a more precise calculation. For bearings with a stainless steel TFE sliding surface the shear deformation shall be determined from the shear force calculated by multiplying dead load reaction with the coefficient of friction for the appropriate bearing surface type in accordance with Table 14.7.2.5-1 of the LRFD specifications.

Combined compression and rotation requirements shall be checked by assuming that dead load and live load reactions are applied to the bearing in combination with live load rotation and initial lack of parallelism as defined below. In addition a check should be made for the case when only dead load reactions are applied to the bearing in combination with the initial lack of parallelism.

Live Load Rotation – shall be taken as the rotation due to the design truck along with the lane load placed on the structure in a manner that produces the maximum rotation. The live load vertical reaction at the bearing shall be the reaction associated with the loading conditions that induce the maximum rotation.

Initial Lack of Parallelism – a rotation of 0.005 radians shall be assumed due to construction tolerances; this initial lack of parallelism includes the net difference between the dead load girder end rotation and the prestress end rotation. However this is not sufficient in many cases to include the effects of the roadway profile grade, consequently the beam seats of a precast concrete girder should be constructed on the same slope as the girder. (The slope of the girder is defined here as the difference in bearing seat elevations of the two girder ends divided by the length of the girder; this is not necessarily the same as the roadway grade.)

Bearing Design Criteria for Steel Girders

Bearing reactions shall be determined from the structural model used for the girder design.

The instantaneous compressive deflection (live load and impact only) shall be less than 1/8". The long term compressive deflection due to dead load including creep shall be limited to 3/16".

Shear deformation shall be determined from the thermal movements of the structure based on the difference between the assumed temperature at placement (normally 60º F per ITD Bridge Design Manual Article 3.12.2.1) and a low temperature of -30° F per LRFD Article 3.12.2.1. For bearings with a stainless steel TFE sliding surface the shear deformation shall be determined from the shear force calculated by multiplying dead load reaction with the coefficient of friction for the appropriate bearing surface type in accordance with Table 14.7.2.5-1 of the LRFD specifications.

Combined compression and rotation requirements shall be checked by assuming the dead load and live load reactions, as determined above, are applied to the bearing in combination with the dead load rotation (for non-cambered girders only), live load rotation and initial lack of parallelism as defined below. In addition a check should be made for the case when only dead load reactions are applied to the bearing in combination with the initial lack of parallelism.

Dead Load Rotations – need only be included for girders constructed of rolled sections that have not been cambered. Cambered girders should have no net dead load rotation.

Live Load Rotation – shall be taken as the rotation due to the design truck along with the lane load placed on the structure in a manner that produces the maximum rotation. The live load vertical reaction at the bearing shall be the reaction associated with the loading conditions that induce the maximum rotation.

Initial Lack of Parallelism – a rotation of 0.005 radians shall be assumed due to construction tolerances. However this is not sufficient in many cases to include the effects of the roadway profile grade. A beveled sole plate shall be used to compensate for grade. Consequently the bearing surfaces on the abutments and piers should be constructed level for steel structures.

Bearing Details

Steel reinforced elastomeric bearings shall consist of alternating layers of a minimum of 14 gage A36 steel and neoprene (or polyisoprene when grade 4 is specified) bonded together. All internal layers of neoprene shall be of equal thickness, there is no limit on the maximum thickness of internal layers as there was in previous specifications provided all design criteria are met. However, the minimum thickness of internal layers should be 3/16" so that a minimum external layer does not violate the requirement to be no more than 70% of the thickness of an internal layer (Article 14.7.5.1). Exterior layers shall have a minimum thickness of 1/8" to provide enough cover to protect the reinforcement.

Information for Required Testing

All steel reinforced elastomeric bearings are to be tested for the Short-Duration Compression Test (subsection 711.02 {5d}). In order to perform this test the maximum design load for each bearing size and type is required. Therefore the method (A or B) that was used in design, along with the maximum design load for each size and type of bearing, must be called out on the bearing detail sheet so that all the information for fabrication and testing is available in one place.

Replacement of Bearings

Refer to Article 2.5.2.3 in the ITD Bridge LRFD Manual for jacking the superstructure of bridges that have replaceable bearings.

Commentary

In most cases design Method A should produce a reasonable size bearing pad. While Method B will in most cases produce a smaller thinner bearing, the time and expense of the required long term compression test is not conducive to getting several bearing suppliers to bid for these projects. WSDOT, which uses elastomeric bearings as their main bearing type, designs the majority of their bearings with Method A.

While it may be somewhat advantageous to specify the shear modulus rather than the hardness of the elastomer, the modulus is still allowed to vary by as much as 15% from the specified value. The allowable shear modulus variance when hardness is specified is not significantly greater than this. In addition the test for shear modulus is a destructive test and would require that extra bearings be fabricated.

When Grade 4 elastomer is specified polyisoprene (natural rubber) will be allowed since it is very difficult for neoprene to meet the low temperature requirements for Grade 4. While neoprene has superior weather and ozone resistance, natural rubber has superior low temperature properties.

At the request of some manufacturer's a minimum steel laminate thickness of 14 gage should be used in order to provide sufficient stiffness of the laminates during fabrication to maintain uniform layer thickness.

Revisions

September 22, 2003 –	Added the requirement for the live load reaction to be the reaction associated with the load inducing maximum rotation when checking rotation. The live load distribution used to calculate rotation was revised to be consistent with the distribution for moment.
December 2, 2003 –	The minimum steel laminate thickness was increased from 16 to 14 gage.
May 13, 2004 –	Added the requirement for Grade 4 elastomer to be natural rubber (polyisoprene) and Grade 3 elastomer to be neoprene (polychloroprene).
September 1, 2004	Added a reference for jacking the superstructure of bridges with replaceable bearings.